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SMPTE REGISTERED DISCLOSURE DOCUMENT

Material Exchange Format — Mapping and Application of Apple ProRes

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Introduction

This section is entirely informative and does not form an integral part of this Registered Disclosure Document (RDD).

ProRes is a picture-by-picture (intra-frame) compression scheme. This RDD specifies the mapping of ProRes bitstreams (SMPTE RDD 36) into a subset of the MXF Generic Container (SMPTE ST 379-2:2010). This RDD also describes application considerations.

MXF file encoders (file writers) require a ProRes bitstream for each picture, each picture's bitstream length, and additional technical metadata items. This metadata can be provided by a ProRes encoder or an application that synthesizes or acquires a ProRes bitstream from another source.

The goals for this MXF specification are to be straightforward to implement, to be as constrained as possible to maximize interoperability, but to be sufficient for the needs of:

- Video camera recording.
- Use in broadcast environments, including playout servers and asset management systems.
- Use in professional video editing and preview, which require: fast file-open time, efficient file playback, and ability to edit while file is being recorded.
- Compatibility considerations for applications such as IMF and AS-11.

References to other documents have the section or table number and the section title or table caption in parentheses.

1 Scope

This Registered Disclosure Document (RDD) specifies the mapping of ProRes bitstreams into a subset of the MXF Generic Container (SMPTE ST 379-2:2010). This document also defines application restrictions. The ProRes bitstream is documented by SMPTE RDD 36. ProRes bitstreams are mapped into a Picture Essence Track of the MXF Generic Container with Frame Wrapping. This RDD defines the KLV coding, the required Keys (Universal Labels) and MXF Picture Essence Descriptor items.

2 Conformance Notation

This RDD uses the conformance notation specified in SMPTE ST 377-1:2019.

3 Normative References

The following standards and related documents contain provisions that, through reference in this text, constitute provisions of this RDD. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this RDD are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

SMPTE ST 377-1:2019, Material Exchange Format (MXF) — File Format Specification

SMPTE RDD 36, Apple ProRes Bitstream Syntax and Decoding Process

SMPTE ST 379-2:2010, Material Exchange Format (MXF) — MXF Constrained Generic Container

SMPTE ST 2049:2012, Low Latency Streaming MXF OP 1a

SMPTE ST 2067-5:2020, Interoperable Master Format — Essence Component

4 Glossary of Acronyms, Terms and Data Types

The general glossary of acronyms, terms and data types used in the MXF specification is given in SMPTE ST 377-1:2019 and is supplemented in SMPTE ST 379-2:2010. These glossaries are not repeated here to avoid any divergence of meaning. In this document, terms are used as defined by SMPTE ST 377-1:2019 in preference to any definition specific to SMPTE ST 379-2:2010.

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5 ProRes Mapping Specifications and Application Considerations

The ProRes container shall be compliant with SMPTE ST 379-2:2010 with constraints defined in the following sections.

5.1 Essence Containers

5.1.1 Files with a Single Picture Essence Track

A Content Item is comprised of one or more Content Element(s), each of which shall contain a single picture (one full video frame) as illustrated in Figure 1.

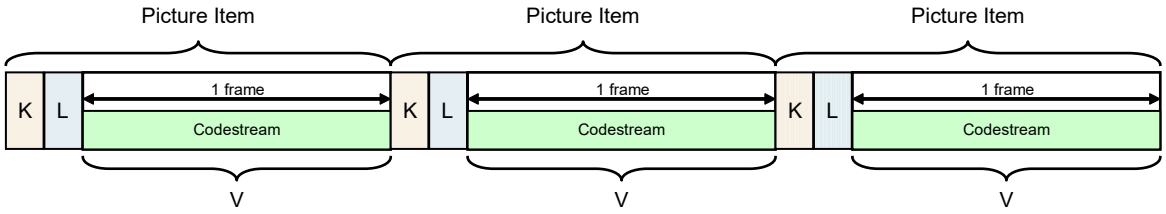

Figure 1 – Frame Wrapping of Picture Elements in the Generic Container

5.1.2 Files with Multiple Essence Tracks

The ProRes pictures may be interleaved with other essence components (Sound or Data) in the Frame Wrapped Essence Container as illustrated in Figure 2. Other essence components shall be as defined by an MXF mapping standard or a SMPTE RDD. All Essence Elements (Generic Container Content Elements) shall be Frame Wrapped. Each Picture (one full video frame) should contain essence data that is independent of adjacent pictures.

Other MXF standards may place additional requirements on the Content Element sequences in a Content Package.

Note: The term Frame Wrapping is defined by SMPTE ST 379-2:2010 as the individual wrapping of one Content Package having a basic sample unit. This basic sample unit is defined by the ProRes bitstream and can be the result of compression of two fields from an interlaced scanned picture or one frame from a progressively scanned picture.

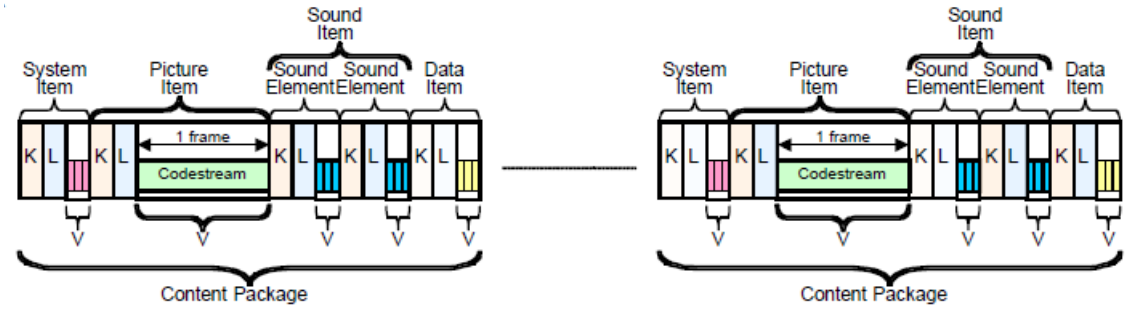

Figure 2 – Frame Wrapping of interleaved items and elements in the Generic Container

Note: Interleaving Essence Elements sometimes involve timing tolerances whose specification is beyond the scope of this RDD. However, the design of the frame based interleaved Generic Container is well established for time aligned Essence Elements within each Content Package.

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5.2 Generic Container Mapping

All Content Elements shall use Frame Wrapping as defined in the Generic Container (SMPTE ST 379-2:2010). Each Picture Element shall contain an individual KLV wrapped picture (one progressive video frame or two interlaced video fields). All pictures in a track shall have the same image characteristics described from the linked Picture Essence Descriptor.

Each Frame Wrapped Generic Container Content Package is a separate editable unit with synchronized System, Picture, Sound and Data Items.

A System Item may be included in a Content Package.

Note: SMPTE ST 379-2:2010 Section 8.2 (Content Items and Content Elements) has additional information.

5.3 Essence Segmentation and Index Tables

5.3.1 General

The file should conform to one of the following essence segmentation and index table schemes:

- Section 5.3.2
- Section 5.3.3
- SMPTE ST 2067-5:2020
- SMPTE ST 2049:2012

Note 1: Application requirements dictate the essence segmentation and index table scheme.

Note 2: Implementations that conform to this specification do not necessarily support all the schemes above and future editions of this document might define new schemes or deprecate schemes.

5.3.2 Files That Are Not Segmented

A file that includes Essence in only one Partition (and does not break Essence into multiple Partitions) shall use a Header Partition or a Body Partition for the Essence. An Essence Container in a single Partition may be of any duration.

In such a file, all Index Tables shall be stored in the Footer Partition, the Header Partition, or both.

5.3.3 Files with Essence Segmented into Fixed Duration Partitions

The first Partition containing Essence shall be a Body Partition.

The duration of all Body Partitions, with the possible exception of the final Body Partition, should be approximately 10 seconds and all Body Partitions shall be less than or equal to 10.01 seconds in duration. The duration of the final Body Partition may be less than the other Body Partitions. The duration of all Body Partitions shall be constant (measured in time or Edit Units) with the possible exception of the final Body Partition.

Body Partition durations in Edit Units and seconds should follow the values documented in Table 1.

Table 1 – Partition Durations (Informative)

Frame Rate	Partition Duration (Edit Units)	Partition Duration (seconds)
24/1.001p	240	10.01
24p	240	10
25p and 25i	240	9.6
30/1.001p and 30/1.001i	300	10.01

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Frame Rate	Partition Duration (Edit Units)	Partition Duration (seconds)
50p	480	9.6
60/1.001p	600	10.01

Note: The Partition durations are chosen as a compromise between Partition size and Partition durations based on established MXF implementations to facilitate interoperability.

Each Body Partition with the exception of the first Body Partition shall include an Index Table for the previous Body Partition from the same Essence Container.

All Index Table Segments shall be repeated at the end of the file. Files with a single File Package shall repeat all Index Table Segments in the Footer Partition. Files with multiple File Packages shall repeat all Index Table Segments for all streams in the last Partition of each stream that includes Index Table Segments.

Notes:

1) Files with segmented Essence Containers can be decoded while being recorded.
2) If an application normally requires that Essence Containers be segmented, short files (less than 10 seconds), can be encoded using the rules in this section.
3) SMPTE ST 377-1:2019, Section 6.2.1 (Partition Rules Summary) summarizes the use of partitions in MXF files.
4) SMPTE EG 377-3 provides examples of how Index Tables can be created for both mono-essence and multi-essence mappings and for both constant and variable length Edit Unit sizes.

5.4 Random Index Pack

The file shall include a Random Index Pack. See SMPTE ST 377-1:2019.

5.5 Header Metadata and Descriptor Property Values

5.5.1 Local Set and Pack Tags

If Static Local Tags have been previously defined, these should be used for KLV Sets and Packs. Static Local Tags are defined in SMPTE ST 377-1:2019. Dynamic Local Tags shall be used when Static Local Tags have not been defined.

5.5.2 Edit Rate

The Edit Rate for ProRes essence in Header Metadata, Index Table Segments and Descriptors shall be calculated based on one frame (or two fields). For additional information see SMPTE ST 377-1:2019, Section 9.5.3 (Material Package), Section 11.2.3 (Index Table Segment), Annex B.12 (Timeline Track) and Annex G.2.2 (Sample Rate and Edit Rate).

Note: The Edit Rate for other Essence Tracks in Header Metadata is defined in SMPTE ST 377-1:2019, Section 9.4 (Structural Metadata Semantics).

5.5.3 Sample Rate

The Sample Rate item for ProRes essence in Header Metadata, Index Table Segments and Essence Descriptors shall be calculated based on one frame (or two fields). For additional information see SMPTE ST 377-1:2019, Annex F.2 (File Descriptor) and Annex G.2.2 (Sample Rate and Edit Rate).

5.5.4 ContainerConstraintSubDescriptor (informative)

The ContainerConstraintSubDescriptor is present as specified in ST 379-2:2010.

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5.6 KAG and KLV Fill Items

MXF encoders and decoders shall comply with the KAG rules defined in SMPTE ST 377-1:2019, Section 6.4.1 (KLV Alignment Grid). The KLV Fill item can be used to maintain a constant Content Package size.

A KAG value of 1 should be used. Other KAG values may be used within the range allowed by SMPTE ST 377-1:2019, Section 6.4.1 (KLV Alignment Grid).

Note: The KLV Fill item can be used to provide a constant Edit Unit size for all pictures.

5.7 Run-In

The file shall not include an MXF file Run-In.

5.8 Mapping Track Numbers to Generic Container Elements

Each Track Number value for an Essence Element defined in this RDD shall be derived as described in the MXF Generic Container standard (SMPTE ST 379-2:2010).

6 KLV Coding and Universal Label Specifications

6.1 ProRes Profiles

ProRes is an intra-frame codec that can encode either progressive or interlaced frames with arbitrary dimensions and either 4:2:2 or 4:4:4 chroma sampling. The compressed size of each frame is variable and dependent on image content, resolution, and the ProRes profile. The 4:4:4 profiles can optionally support an alpha channel with either 8 or 16-bit sample depth.

Table 2 defines the ProRes profile names, their attributes and values.

Note: Nominal bit rates are provided for 1920 x 1080 and 3840 x 2160 pictures at 24 fps. Actual bit rates are variable and content dependent. Alpha channel compression is lossless and does not have a nominal bit rate.

Table 2 – ProRes Profiles

Profile name	Chroma sampling	Alpha sample depth	Nominal bit rate (informative)	
			1920 x 1080 at 24 fps	3840 x 2160 at 24 fps
422 Proxy	4:2:2	No alpha	36 Mb/s	145 Mb/s
422 LT	4:2:2	No alpha	82 Mb/s	329 Mb/s
422	4:2:2	No alpha	117 Mb/s	472 Mb/s
422 HQ	4:2:2	No alpha	176 Mb/s	707 Mb/s
4444	4:4:4	No alpha	264 Mb/s	1.06 Gb/s
4444	4:4:4	8 or 16		
4444 XQ	4:4:4	No alpha	396 Mb/s	1.59 Gb/s
4444 XQ	4:4:4	8 or 16		

6.2 ProRes Essence Element KLV Coding

6.2.1 ProRes Picture Element Key

ProRes Picture Essence is Frame Wrapped and the Key (Universal Label) defined in Section 6.3 shall be used.

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6.2.2 Essence Element Length

The KLV length field BER coding for ProRes video Content Elements shall be five bytes.

Note: The five byte KLV length field is needed for high resolution with high data rates.

6.2.3 Essence Element Value

The Essence Element KLV value for progressive pictures shall be one video frame, and for interlaced pictures the KLV value shall be two fields from a single video frame.

6.3 ProRes Picture Element Key

The values of the bytes of the Essence Element Key are defined in SMPTE ST 379-2:2010, Section 10.1 (Essence Element Key).

The Picture Element Key shall be as specified in Table 3.

Table 3 – ProRes Picture Element Key

Item	Value
UL	060E2B34.01020101.0D010301.15cc17nn
Kind	LEAF
Definition	Identifies a frame-wrapped ProRes Picture Element

Note: The bytes in this UL are used as follows:

- Bytes 1-12 are defined by SMPTE ST 379-2:2010.
- Byte 13 is the GC Picture Item identifier.
- Byte 14 is the count of Picture Elements in the Picture Item.
- Byte 15 identifies a Frame Wrapped ProRes Picture Essence Element Type.
- Byte 16 is the Essence Element Number (used as an Index) of this Picture Element in the Picture Item.

6.4 ProRes Essence Container Label

The Essence Container Label is used within a Batch of ULs in Partition Packs and the Preface Set and in the Essence Descriptor. The Essence Container Key is defined in SMPTE ST 379-2:2010, Section 11 (SMPTE Essence Container Label).

The Essence Container Label shall be as specified in Table 4.

Table 4 – ProRes Essence Container Label

Item	Value
Symbol	MXFGCFrameWrappedEssenceContainerProResPicture
UL	060E2B34.0401010D.0D010301.021C0100
Kind	LEAF
Name	MXF-GC Frame-Wrapped Essence Container ProRes Picture
Definition	Identifier for MXF-GC Frame-Wrapped Essence Container ProRes Picture

Note: The bytes in this UL are used as follows:

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- Bytes 1-12 are defined by SMPTE ST 379-2:2010.
- Byte 13 is the Essence Container Kind for a Generic Container.
- Byte 14 is the Mapping Kind for a ProRes Picture Element.
- Byte 15 is the identifier for the Content Kind for a Frame Wrapped Picture Element.
- Byte 16 is not used.

6.5 ProRes Picture Essence Coding Label

The ProRes Picture Essence Coding Label is used in the Generic Picture Essence Descriptor. These labels are listed in the SMPTE Metadata Registers.

The Picture Essence Coding Label shall be one of the labels specified in Table 5.

Table 5 – Specification of the ProRes Picture Essence Coding Label

Symbol	UL	Definition
ProResPictureCoding422Proxy	060E2B34.0401010D.04010202.03060100	Identifies ProRes Picture coding for the 422 Proxy profile
ProResPictureCoding422LT	060E2B34.0401010D.04010202.03060200	Identifies ProRes Picture coding for the 422 LT profile
ProResPictureCoding422	060E2B34.0401010D.04010202.03060300	Identifies ProRes Picture coding for the 422 profile
ProResPictureCoding422HQ	060E2B34.0401010D.04010202.03060400	Identifies ProRes Picture coding for the 422 HQ profile
ProResPictureCoding4444	060E2B34.0401010D.04010202.03060500	Identifies ProRes Picture coding for the 4444 profile
ProResPictureCoding4444XQ	060E2B34.0401010D.04010202.03060600	Identifies ProRes Picture coding for the 4444 XQ profile

Note: The bytes in these ULs are used as follows:

- Bytes 1-8 are a defined in SMPTE ST 400.
- Byte 9 identifies parametric data.
- Byte 10 identifies picture essence coding.
- Byte 11 identifies picture coding characteristics.
- Byte 12 identifies compressed picture coding.
- Byte 13 identifies individual picture coding schemes.
- Byte 14 identifies ProRes picture coding.
- Byte 15 identifies a ProRes picture coding profile.
- Byte 16 is not used.

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7 MXF Descriptors

7.1 File and Structural Descriptors

The File Descriptor Sets are Structural Metadata Sets in the Header Metadata that describe the essence and metadata elements defined by this RDD. The structure of these sets is defined in the MXF File Format Specification (SMPTE ST 377-1:2019).

ProRes uses the Color Difference Component Image (CDCI) Picture Essence Descriptor or the Red Green Blue Alpha (RGBA) Picture Essence Descriptor. These Descriptors are defined in SMPTE ST 377-1:2019, Annex F.4 (Picture Essence Descriptors). The meaning of the items in the CDCI and RGBA Picture Essence Descriptors are defined in SMPTE ST 377-1:2019, Annex G (Picture Essence Descriptor Properties).

7.2 ProRes Compression of Television Formats

ProRes can be used to compress most SMPTE standardized television formats. For progressive and interlaced formats, one ProRes Content Element shall be one progressive video frame or two interlaced video fields.

The format of the source coding shall be specified in the Frame Layout property in the Generic Picture Essence Descriptor. This indicates whether the source picture was full frame (for progressive) or separate fields (for interlaced).

The values for the Essence Descriptor items given in Table 6 and Table 7 should be used. A description of the “Item Name” and “Meaning” columns in these tables shall be used as defined in SMPTE ST 377-1:2019 unless otherwise noted.

Additional Generic Picture Essence Descriptor properties may be included in accordance to SMPTE ST 377-1:2019.

7.3 Generic Picture Essence Descriptor

The values in Table 6 should be used for the Generic Picture Essence Descriptor property values. Additional Generic Picture Essence Descriptor items from SMPTE ST 377-1:2019 may be used.

Table 6 – Generic Picture Essence Descriptor Items (Normative)

Item Name	Meaning	Value
Signal Standard	Underlying Signal Standard. See ST 377-1 Annex G.2.3:2019, (Signal Standard).	Should be equal to 0.
Frame Layout	Interlace or progressive layout. See ST 377-1 Annex G.2.1:2019, (Frame Layout).	For progressive formats, 0 (full_frame) shall be used. For interlaced formats, 1 (separate_fields) shall be used. For progressive segmented frames, 4 (segmented_frame) shall be used.
Stored Width	Horizontal Size of stored picture. See ST 377-1:2019, Annex G.2.6 (Stored Width).	Shall be equal to the horizontal_size parameter specified at RDD 36.
Stored Height	Vertical Field Size of stored picture. See ST 377-1:2019, Annex G.2.7 (Stored Height).	For progressive formats, shall be equal to the vertical_size parameter specified at RDD 36. For interlaced formats, shall be equal to the bottomFieldVerticalSize parameter specified at RDD 36.

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Item Name	Meaning	Value
Sample Width	See ST 377-1:2019, Annex G.2.8 (Sampled Width).	Shall be absent or equal to Stored Width.
Sample Height	See ST 377-1:2019, Annex G.2.8 (Sampled Width).	Shall be absent or equal to Stored Height.
SampledXOffset	See ST 377-1:2019, Annex G.2.10 (SampledXOffset).	Shall be absent or equal to 0.
SampledYOffset	See ST 377-1:2019, Annex G.2.11 (SampledYOffset).	Shall be absent or equal to 0.
DisplayHeight	Displayed height placed in Production Aperture. See ST 377-1:2019, Annex G.2.14 (DisplayHeight).	As described in ST 377-1:2019.
DisplayWidth	Displayed width placed in Production Aperture. See ST 377-1:2019, Annex G.2.13 (DisplayWidth).	As described in ST 377-1:2019.
DisplayXOffset	Offset from Sampled Width to Display Width. See ST 377-1:2019, Annex G.2.15 (DisplayXOffset).	As described in ST 377-1:2019.
DisplayYOffset	Offset from Sampled Height to Display Height. See ST 377-1:2019, Annex G.2.16 (DisplayYOffset).	As described in ST 377-1:2019.
DisplayF2Offset	See ST 377-1:2019, Annex G.2.17 (DisplayF2Offset).	For interlaced formats: • Shall be equal to 0 if the interlace_mode parameter specified at RDD 36 is equal to 1; or • Shall be equal to -1 if the interlace_mode parameter specified at RDD 36 is equal to 2.
Aspect Ratio	Specifies the horizontal to vertical aspect ratio of the whole image as it is to be presented to avoid geometric distortion. See ST 377-1:2019, Annex G.2.4 (Aspect Ratio).	The rational value carried by the Aspect Ratio item is not necessarily irreducible. Example: The Aspect Ratio item can be equal to 1920/1080, even though the fraction is reducible to 16/9.
Video Line Map	First active line in each field. See ST 377-1:2019, Annex G.2.12 (Video Line Map).	Should be equal to 0.
Transfer Characteristic	Specifies the opto-electric transfer characteristic. See ST 377-1:2019, Annex G.2.21 (Transfer Characteristic).	Individual UL values are listed in the SMPTE Metadata Registers.
Picture Essence Coding	UL identifying the Picture Coding Scheme. See ST 377-1:2019, Annex G.2.25 (Picture Essence Coding).	See Section 6.5.

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Item Name	Meaning	Value
Coding Equations	Specifies the encoding equations to convert RGB image components to component color difference image components.	Shall be present. Individual UL values are listed in the SMPTE Metadata Registers. Note: The Coding Equations item is required even when the RGBA Picture Essence Descriptor is used.
Color Primaries	Specifies the color primaries.	Individual UL values are listed in the SMPTE Metadata Registers.

7.4 CDCI (Color Difference Component Image) Picture Essence Descriptor

The CDCI Descriptor should be used when the source picture uses color difference components.

Note: The CDCI Descriptor can also be used for RGB (or RGBA) source pictures. The Coding Equations item specifies the conversion between RGB and color difference component values, which allows the CDCI Descriptor to be used for RGB source pictures.

Additional CDCI Descriptor items from SMPTE ST 377-1:2019 may be used.

Table 7 – CDCI Picture Essence Descriptor Items (Normative)

Item Name	Meaning	Value
Horizontal Subsampling	Specifies the horizontal color subsampling. See ST 377-1:2019, Annex G.2.27 (Horizontal Subsampling).	1 for 4444 and 4444 XQ and otherwise 2
Vertical Subsampling	Specifies the vertical color subsampling. See ST 377-1:2019, Annex G.2.28 (Vertical Subsampling).	1
Alpha Sample Depth	Number of bits per alpha sample. See ST 377-1:2019, Annex G.2.31 (Alpha Sample Depth).	8 or 16 This property shall be omitted if alpha samples are not present.

Note: The Alpha Sample Depth item can be omitted to signal opaque 4444 and 4444 XQ content.

7.5 RGBA (Red Green Blue Alpha) Picture Essence Descriptor

The RGBA Descriptor may be used when the source picture consists of Red, Green, Blue, and Alpha components.

Additional RGBA Descriptor items from SMPTE ST 377-1:2019 may be used.

Table 8 – RGBA Picture Essence Descriptor Items (Normative)

Item Name	Meaning	Value
PixelLayout	See ST 377-1:2019, Annex G.2.36 and G.2.40	See the provisions following this table.

Essence that is known to contain entirely opaque alpha components shall be signaled by replacing the PixelLayout Alpha Code with a PixelLayout Fill Code of the same size. If the alpha components are not

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known to be entirely opaque, the Alpha Code of the PixelLayout item should be used as described in SMPTE ST 377-1:2019.

Note: Signaling that content is opaque enables some systems to take advantage of performance optimizations when displaying the content.

7.6 Color Items for MXF Descriptors (Informative)

The information in Table 9 can be used for the Generic Picture Essence Descriptor items: Color Primaries, Transfer Characteristic and Coding Equations.

Note: The reader is encouraged to review the SMPTE Metadata Registers for additional item values.

Table 9 – Video Signal Formats and Color items

Signal Format	Items and Values
ITU-R BT.601 (525-line system)	**Color Primaries:** Symbol: ColorPrimaries_SMPTE170M UL: 060E2B34.04010106.04010101.03010000 **Transfer Characteristic:** Symbol: TransferCharacteristic_ITU709 UL: 060E2B34.04010101.04010101.01020000 **Coding Equations:** Symbol: CodingEquations_ITU601 UL: 060E2B34.04010101.04010101.02010000
ITU-R BT.601 (625-line system)	**Color Primaries:** Symbol: ColorPrimaries_ITU470_PAL UL: 060E2B34.04010106.04010101.03020000 Note: Equivalent to EBU 3213 color primaries for non-M systems **Transfer Characteristic:** Symbol: TransferCharacteristic_ITU709 UL: 060E2B34.04010101.04010101.01020000 **Coding Equations:** Symbol: CodingEquations_ITU601 UL: 060E2B34.04010101.04010101.02010000
ITU-R BT.709	**Color Primaries:** Symbol: ColorPrimaries_ITU709 UL: 060E2B34.04010106.04010101.03030000 **Transfer Characteristic:** Symbol: TransferCharacteristic_ITU709 UL: 060E2B34.04010101.04010101.01020000 **Coding Equations:** Symbol: CodingEquations_ITU709 UL: 060E2B34.04010101.04010101.02020000

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Signal Format	Items and Values
ITU-R BT.2020	**Color Primaries:** Symbol: ColorPrimaries_ITU2020 UL: 060E2B34.0401010D.04010101.03040000 **Transfer Characteristic:** Symbol: TransferCharacteristic_ITU2020 UL: 060E2B34.0401010E.04010101.01090000 **Coding Equations:** Symbol: CodingEquations_ITU2020_NCL UL: 060E2B34.0401010D.04010101.02060000
ITU-R BT.2100 (PQ system)	**Color Primaries:** Symbol: ColorPrimaries_ITU2020 UL: 060E2B34.0401010D.04010101.03040000 **Transfer Characteristic:** Symbol: TransferCharacteristic_SMPTEST2084 UL: 060E2B34.0401010D.04010101.010A0000 **Coding Equations:** Symbol: CodingEquations_ITU2020_NCL UL: 060E2B34.0401010D.04010101.02060000
ITU-R BT.2100 (HLG system)	**Color Primaries:** Symbol: ColorPrimaries_ITU2020 UL: 060E2B34.0401010D.04010101.03040000 **Transfer Characteristic:** Symbol: TransferCharacteristic_HLG_OETF UL: 060E2B34.0401010D.04010101.010B0000 **Coding Equations:** Symbol: CodingEquations_ITU2020_NCL UL: 060E2B34.0401010D.04010101.02060000
P3D65 PQ (COLOR.6 as specified at SMPTE ST 2067-21)	**Color Primaries:** Symbol: ColorPrimaries_P3D65 UL: 060e2b34.0401010d.04010101.03060000 **Transfer Characteristic:** Symbol: TransferCharacteristic_SMPTEST2084 UL: 060E2B34.0401010D.04010101.010A0000 **Coding Equations:** Symbol: CodingEquations_ITU709 UL: 060E2B34.04010101.04010101.02020000

Note: ITU-R BT.601 transfer characteristics are represented by the ITU-R BT.709 UL.

8 Summary of changes (informative)

The following summarizes the modifications made since the previous edition of the specification:

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- Imposed requirements on Sampled Rectangle, Stored Height and Coding Equations
- Recommended values for Signal Standard and Video Line Map
- Moved DisplayF2Offset constraints from RDD 45
- Added P3D65 PQ example to Table 9
- Clarified requirements for essence segmentation and index tables, including adding support for SMPTE ST 2049:2012.
- Updated normative references

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Annex A Bibliography (Informative)

SMPTE Metadata Registers, url: https://smpte-ra.org

SMPTE EG 377-3, Material Exchange Format (MXF) — Engineering Guideline (Informative)

Recommendation ITU-R BT.601, Studio encoding parameters of digital television for standard 4:3 and wide-screen 16:9 aspect ratios

Recommendation ITU-R BT.709, Parameter values for the HDTV standards for production and international programme exchange

Recommendation ITU-R BT.2020, Parameter values for ultra-high definition television systems for production and international programme exchange

Recommendation ITU-R BT.2100, Image parameter values for high dynamic range television for use in production and international programme exchange

SMPTE ST 2067-21, Interoperable Master Format — Application #2E

SMPTE ST 400, SMPTE Labels Structure

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